Preliminary Model of Time as Relational Sheen in a 4D Filamentary Spacetime

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Abstract

We propose a model where time and its flow emerge from relational structures between filamentary worldlines embedded in a 4D differentiable manifold without prior metric or connection. Local shearing and misalignment among filaments define a scalar field, the relational *sheen*, which governs local proper time flow. We present the construction of the relational strain tensor, define the sheen scalar field, and propose dynamics for its evolution. Proper time increments are determined by the rate o...

1 Introduction

We consider a smooth 4-dimensional differentiable manifold M, without a priori given metric, connection, or gauge structures. The manifold is populated by a dense ensemble of smooth curves, termed *filaments*, representing fundamental constituents.

Each filament is a smooth embedding:

$$\gamma : \mathbb{R} \to M, \quad \lambda \mapsto \gamma^\mu(\lambda), \tag{1}$$

with λ an affine parameter along the filament, and $v^\mu = d\gamma^\mu/d\lambda$ the tangent vector.

2 Emergent Metric and Connection

We define the local co-metric at each point $x \in M$ via the ensemble average:

$$\tilde{g}_{\mu\nu}(x) = \langle v_\mu v_\nu \rangle . \tag{2}$$

Provided $\tilde{g}_{\mu\nu}(x)$ is non-degenerate, its inverse $g^{\mu\nu}(x)$ exists, yielding the emergent metric $g_{\mu\nu}(x)$. We then define the Levi-Civita connection ∇_μ as the unique torsion-free, metric-compatible connection:

$$\nabla_\alpha g_{\mu\nu} = 0. \tag{3}$$

All covariant derivatives and index contractions henceforth refer to this emergent metric structure.

3 Filament Current and Emergent Time

The local filament current is defined as:

$$J^\mu(x) = \sum_\gamma \int d\lambda\, v^\mu(\lambda)\, \delta^{(4)}(x - \gamma(\lambda)). \tag{4}$$

We define the emergent time direction vector field:

$$\tau^\mu(x) \propto J^\mu(x), \tag{5}$$

where the proportionality factor can be fixed by normalization conditions with respect to the emergent metric.

We introduce a scalar field $\phi(x)$ such that the emergent foliation is defined by:

$$d\phi = \tau_\mu dx^\mu. \tag{6}$$

4 Relational Strain and Sheen Scalar

Consider two neighboring filaments $\gamma_1(\lambda)$ and $\gamma_2(\lambda)$. Define the infinitesimal separation vector:

$$\delta x^\mu(\lambda) = \gamma_2^\mu(\lambda) - \gamma_1^\mu(\lambda). \tag{7}$$

The relational strain tensor is defined as:

$$S_{\mu\nu}(\lambda) = \delta x^\alpha(\lambda) \nabla_\alpha v_{(\mu} v_{\nu)}, \tag{8}$$

where symmetrization is taken over μ, ν.

We define the local *sheen* scalar field:

$$S(x) = \sqrt{S_{\mu\nu}(x) S^{\mu\nu}(x)}. \tag{9}$$

This scalar quantifies the root-mean-square misalignment rate between neighboring filaments.

5 Proper Time Flow and Sheen Dynamics

We define the *activation rate* $\omega(x)$ as the derivative of the sheen scalar along the foliation:

$$\omega(x) = \frac{dS(x)}{d\phi}. \tag{10}$$

The local proper time increment is then proposed to be:

$$d\tau \propto \omega(x) d\phi. \tag{11}$$

We postulate that the sheen scalar field evolves according to a scalar wave equation with potential:

$$\Box S(x) - V'(S(x)) = 0, \tag{12}$$

where $\Box$ is the d'Alembertian constructed from the emergent metric $g_{\mu\nu}(x)$.

6 Entropy and Arrow of Time

We propose that the local entropy density $s(x)$ is proportional to the sheen scalar:

$$s(x) \propto S(x). \tag{13}$$

Thus, the local entropy production rate along proper time is:

$$\frac{ds}{d\tau} \propto \omega(x). \tag{14}$$

This provides a natural link between relational misalignment and the thermodynamic arrow of time.

7 Conclusion

We have presented a preliminary model where local relational structures between filamentary worldlines give rise to an emergent notion of time, its flow, and associated entropy increase. The model derives local proper time increments from the rate of relational misalignment, quantified by the sheen scalar. Dynamics for the sheen field suggest a self-consistent evolution linked to emergent spacetime geometry. Further work is required to derive explicit solutions and connect to observable phenomena.

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